

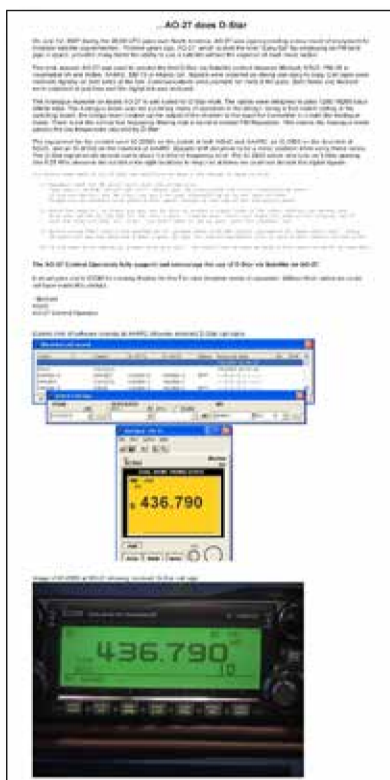
D-Star via AO-27

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AO-27, launched in 1993, has been popular among satellite operators. An FM satellite using a 2m uplink and 70cm downlink, it was one of the first satellites that opened up satellites to those using FM handheld or mobile transceivers. But there is more to AO-27 than its FM operations...

According to the old ao27.org web site¹, AO-27 was originally designed to relay GMSK data at 1200bps to 19200bps. Not FM. Before AO-27's launch, it was modified to serve as an FM repeater, but it did not lose the ability to relay GMSK data. D-Star, developed after AO-27 was launched, happens to use GMSK data at up to 4800bps for voice transmissions². The primary command operator for AO-27, Mike Wyrick N3UC in Virginia, along with Robin Cutshaw AA4RC in Georgia, made what appears to be the first documented D-Star contact via AO-27 on 1 July 2007. Both N3UC and AA4RC used Icom IC-2200 2m FM/D-Star mobile transceivers with the UT-115 digital module for the 2m uplink. N3UC used an IC-2820H 2m/70cm FM/D-Star mobile transceiver with the UT-123 D-Star/GPS module to receive the 70cm downlink, while AA4RC used an IC-91AD 2m/70cm FM/D-Star handheld radio for the downlink.

► **Screen capture from old ao27.org web site detailing AO-27 D-Star contact in 2007**



The DD1US "Sounds from Space" web site³ has an audio recording from Luc VE2DWE (SK), demonstrating D-Star via AO-27 in September 2009⁴. Other than these attempts, there was very little information about past use of D-Star via AO-27. Fast forward to 2021...

Endaf N6UTC/MW1BQO, a satellite operator in southern California, and I started talking early in 2021 about how D-Star had been used through AO-27. We both had D-Star equipment - N6UTC has an Icom IC-80AD 2m/70cm FM/D-Star handheld radio and an Icom ID-880H 2m/70cm FM/D-Star mobile radio, and at that time I had two Kenwood TH-D74 multi-band FM/D-Star handheld radios. So we started to look at AO-27 passes over the US west coast that we could use to start experimenting with D-Star.

When D-Star voice transmissions are made, additional data is sent with the audio. This usually includes the call sign of the transmitting station, along with optional data like a short message or the station location. N6UTC and I were initially wanting to see a call sign show up from a D-Star transmission. This was occasionally successful, and we quickly moved onto attempting a two-way QSO. On the evening of 27 January 2021, N6UTC and I completed our first D-Star QSO via AO-27. We used our two-radio stations, for full-duplex operation.



► **N6UTC's AO-27 D-Star station in January 2021 - photo courtesy Endaf Buckley N6UTC/MW1BQ**



► *(WD9EWK's AO-27 D-Star station in January 2021)*

We repeated this on 28 January. Not only did we complete a QSO, this time we were able to see the call sign of the other station that came along with the D-Star audio.



► *N6UTC received WD9EWK via AO-27 D-Star with an IC-80AD - photo courtesy Endaf Buckley N6UTC/MW1BQO*

► *WD9EWK received N6UTC via AO-27 D-Star with a TH-D74*



Throughout February 2021, N6UTC and I continued our AO-27 D-Star experiments. N6UTC switched between his IC-80AD and ID-880H around on different passes, using both radios, and sometimes trying just one of the radios for half-duplex operation. Later in February 2021, I borrowed an Icom ID-4100 2m/70cm mobile radio, and started using that with one of my TH-D74s. I bought an Icom ID-5100 2m/70cm mobile radio, and begin to try these radios along with a TH-D74, and even trying to work D-Star with just the ID-5100.

As N6UTC and I experiment with D-Star, there are many times where other stations will try to transmit through AO-27 during our transmissions. To an FM receiver, the D-Star signals sound just like static when there is no FM signal present. If you listen closely, the D-Star signals sound different than the normal FM static. N6UTC and I are able to hear the FM traffic when we try to work each other using D-Star. We try to make our transmissions short, and look to complete QSOs quickly. We are even able to make a D-Star QSO with each other, and then join in with the others making FM QSOs on a pass.

In early March 2021, N6UTC and I are now trying to complete D-Star QSOs using a single mobile radio on each end - N6UTC used his ID-880H, and I used either an ID-4100 or ID-5100. The ID-5100 is a great radio for full-duplex operations on FM satellites, but not in D-Star. If I transmit in D-Star on an ID-5100, and the sub VFO receives a D-Star signal, the sub VFO is automatically muted. The ID-5100 will attempt to decode the data sent with the D-Star signal, but the radio's single D-Star vocoder does not allow for full-duplex operation using D-Star. I captured this in a short video on YouTube⁵.



► *WD9EWK's ID-5100 while transmitting D-Star via AO-27*

The ID-5100's main VFO is set for DV mode, with the URCALL parameter set to CQCQCQ - not to any particular station. The "CQCQCQ" appears in the main VFO while transmitting in D-Star (DV). On the sub VFO, "MUTE" appears on the screen, and WD9EWK shows up -

confirmation that my D-Star transmission was making it through AO-27 back to my ID-5100. When I stopped transmitting in D-Star, the sub VFO unmuted.

N6UTC and I have made dozens of D-Star QSOs via AO-27 in 2021, from many different locations. I have worked AO-27 passes using D-Star from several different locations around Arizona, and once on a road trip to southern Utah in June 2021.



► **WD9EWK** at “Welcome to Utah” sign on 18 June 2021

The QSO that is probably the best documented of our D-Star experiments happened on the evening of 12 March 2021. N6UTC used his ID-880H, and I used an ID-4100. We were both operating half-duplex. We also made videos of this contact. N6UTC posted his video on his @N6UTC Twitter feed⁶, and I posted my video⁷ on YouTube. Call signs were received along with some of the D-Star transmissions. My video continues for the remainder of that AO-27 pass. I worked KB6LTY in southern California in FM after my QSO with N6UTC, answering a question about the D-Star QSO N6UTC and I just completed.

During 2021, N6UTC and I have worked a few other stations across the continental USA and Mexico using D-Star via AO-27. All of the other stations we have worked used IC-9700s. John VE1CWJ in Nova Scotia reported on Twitter that he worked Steven KC1MMC in Vermont using

his IC-9700 on 30 April 2021⁸. VE1CWJ reported he configured the DOPPLER.SQL file in SatPC32 to handle D-Star along with FM on AO-27, based on a post in a thread on the QRZ.com satellite forum⁹ that started out discussing the ID-5100. Another thread on the same forum discusses my use of the ID-4100 for D-Star via AO-27¹⁰.

Most Icom D-Star radios have a “DV Auto Detect” menu setting. The Kenwood TH-D74 has a similar menu setting, “FM Auto Det. on DV” (menu 617). These settings allow a VFO set for D-Star (DV) to receive FM signals, without having to switch the VFO to FM mode. This has been useful, so I can monitor other stations working AO-27 in FM. This helps me decide if I will transmit in FM or D-Star. On my radios, I put the 145.850 MHz uplink frequency into two memory channels - one in FM, and the other in DV with the URCALL parameter set to “CQCQCQ”. This allows me to quickly change between FM and D-Star when transmitting through AO-27. I use a VFO to receive the 70cm downlink, set in D-Star (DV) mode, and “DV Auto Detect” enabled. Other than these menu settings, working AO-27 in D-Star is similar to working in FM - the downlink frequency needs to be adjusted during passes to compensate for Doppler, and D-Star radios other than the IC-9700 need to use 5 kHz tuning steps for the 70cm downlink. The IC-9700 can use even smaller tuning steps for D-Star via AO-27, which should make it easier to receive D-Star transmissions.

Over the past few months, I have found that the D-Star audio seems to be tolerant of some Doppler. Once the downlink signal moves too far from the frequency on my receiver, I start hearing R2-D2 noises when the audio can't be cleanly decoded. When I hear this during an AO-27 pass, I can usually tune down 5 kHz to hear the audio again. Since D-Star signals sound like static on an FM receiver, there will be many times where the received audio sounds like R2-D2 due to FM and D-Star signals trying to get

through the AO-27 repeater simultaneously. The data included with a D-Star voice transmission does not appear to be as tolerant of Doppler. There are many occasions, including AO-27 passes in other videos on my YouTube channel, where no call sign appears on the screen while receiving a transmission with decent audio. I do not rely on seeing a call sign from another station to have a good AO-27 D-Star QSO. Seeing the information on the radio's screen is a bonus. The Icom IC-9700, which allows for smaller tuning steps, should be able to avoid the issues related to the Doppler effect on the 70cm downlink. No matter what radio is used to receive a D-Star downlink from AO-27, there is a slight delay in decoding the audio. This can be confusing at first, when operators are used to hearing downlinks with virtually no delay when working full-duplex in other modes like FM, SSB, or CW.

Many thanks to Endaf N6UTC/MW1BQO for convincing me to try D-Star on AO-27, and thanks to all of the stations I have worked using this mode in the past few months. 🌐

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 2. <http://www.jarl.com/d-star/shogen.pdf>
 3. <http://www.dd1us.de/spacesounds%20c.html>
 4. <http://www.dd1us.de/sounds/ao-27%20dstar%20ve2dwe%20calling%20cq.mp3>
 5. <https://www.youtube.com/watch?v=wAMWuCax4bw>
 6. <https://twitter.com/N6UTC/status/1370576891841671170>
 7. <https://www.youtube.com/watch?v=ZGOJUF4gJ24>
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 9. <https://forums.qrz.com/index.php?threads/icom-id-5100-for-fm-satellites-and-d-star-via-ao-27.755389/>
 10. <https://forums.qrz.com/index.php?threads/icom-id-4100-for-fm-satellites-focusing-on-ao-27-and-especially-d-star.755598/>
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